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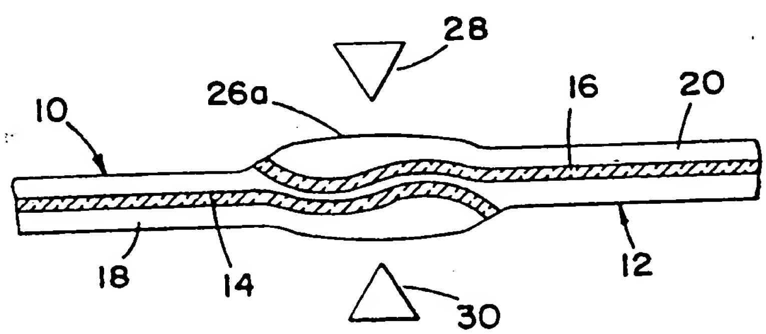
(54) Title: OVERLAPPING FUSION ATTENUATOR



(57) Abstract

A method for fabricating an optical attenuator from first and second optical fibers includes placing the fibers in closely spaced overlapped relation to define an overlapped portion of the fibers. Energy is initially applied to the overlapped portion to at least partially fuse the first and second fibers at the overlapped portion.

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OVERLAPPING FUSION ATTENUATOR

I. BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to a fiber optic attenuator for use in attenuating a signal transmitted over optical fibers.

2. Description of the Prior Art

The use of in-line optical fiber attenuators is well known. Examples of such are shown in U.S. Patent No. 4,529,262; U.S. Patent No. 4,557,557; and U.S. Patent No. 4,557,556.

It is desirable to provide for a method for fabricating a low cost optical fiber attenuator. Furthermore, such a method should be susceptible to producing a variety of attenuators which will produce a variety of desired signal losses. It is an object of the present invention to provide a method of fabricating a low cost attenuator which is susceptible to fabricating attenuators of a wide variety of signal losses.

II. SUMMARY OF THE INVENTION

According to a preferred embodiment of the present invention, a method is disclosed for fabricating an optical attenuator from at least a first and second optical fiber. The method includes the steps of placing the first and second fibers in closely spaced overlapping relation to define an overlapped portion of the fibers. Energy is applied to the overlapped portion to at least partially fuse the first and second fibers at the overlapped portion.

III. BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of two fibers disposed for fusion according to the method of the present invention;

Fig. 2 is a view of the fibers of Fig. 1 after application of energy to the overlapped portion of the fibers;

Fig. 3 is a schematic diagram of an apparatus and optical fibers set up for fabrication according to a further alternative embodiment of the present invention;

Fig. 4 is the view of Fig. 3 showing the fibers after fusion;

Fig. 5 is a view similar to that of Fig. 1 showing a further alternative embodiment of the present invention; and

Fig. 6 is a view of an adapter incorporating a still further attenuator fabricated according to the method of the present invention.

IV. DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Fig. 1, optical fibers 10 and 12 are shown in preparation for fusion according to the method of the present invention. Each of fibers 10,12 include a signal transmitting core 14,16 surrounded by a cladding 18,20. The fibers terminate at terminal ends 22,24. The fibers 10,20 are of commercial construction and have an outside diameter D_0 of about .125 millimeters. The cores of each of the fibers have a diameter D_c of about .010 millimeters for single mode fibers and about .050 millimeters for multi-mode fibers. The fibers 10,12 are connected to signal sources and receivers (not shown) such that an optical signal can be sent through the fibers 10,12 and the transmission loss through the fibers 10,12 can be measured during the method of the present invention.

As shown in Fig. 1, the fibers 10,12 are disposed in parallel side-by-side abutting and overlapping relation.

Specifically, as shown in Fig. 1, the axis X-X of fiber 10 is disposed in parallel and spaced apart alignment from the axis Y-Y of fiber 12. The cladding 18 of fiber 10 abuts the cladding 20 of fiber 12. As a result, the fibers cooperate to define an overlapped portion 26 having a length D_1 which, in a preferred embodiment, is about .5 millimeters.

As shown in Fig. 1, the overlapped portion 26 is disposed between the electrodes 28,30 of an electrical arc generator. The complete generator is not shown and is a commercially available item to produce an arc between electrodes 28,30. In a preferred embodiment, the generator will produce an arc having a current flow of about .05 to .06 amps between electrodes 28,30. The arc produced by the electrodes 28,30 is an energy source for fusing the fibers, as will be described. It will be appreciated by those skilled in the art that any energy source could be used. Examples of alternative energy sources would be lasers or other heat sources.

In the method of the present invention, the electrodes 28,30 are energized to create a pulse arc of about one second duration to apply energy to the overlapped portion 26. By reason of the application of this energy, the cladding 18,20 partially melt and fuse together as shown in Fig. 2, such that the fibers 10,20 are now joined by a fused overlapped portion 26a.

After the initial fusion, the amount of signal transmission loss through the now coupled fibers 10,12 is measured. If the transmission loss is greater than a desired loss for an attenuator to be produced according to the present fabrication technique, a subsequent application of energy is supplied to portion 26a by passing a further arc between electrodes 28,30. The subsequent application of energy causes further fusing of the overlapped portion 26a. As a result of this further fusing, the cores 14,16 in region 26a move closer together resulting in reduced transmission loss.

Accordingly, multiple fuses results in the cores 14,16 moving progressively together with a resulting progressive decrease in the amount of transmission loss through the fibers 10,12.

As a result, the method of the present invention, includes application of energy to the overlapped portion 26 to at least partially fuse the fibers 10,12 in the overlapped portion 26. Following the application of energy, transmission loss through the fibers 10,12 is measured. If the transmission loss is greater than a desired transmission loss, subsequent applications of energy are applied. After each application of energy, the transmission loss through the fibers 10,12 is measured. The subsequent applications of energy followed by subsequent measurements of the transmission loss is continued until a desired transmission loss is attained.

From the foregoing, it can be seen how an attenuator of varying transmission losses can be attained. For example, transmission losses of 12,15 or 20 dB (or any other dB greater than 10dB) can be attained simply by controlling the amount or number of applications of energy to the overlapped portion 26.

The foregoing preferred embodiment is adequate for producing attenuators having transmission losses of greater than or equal to 10 dB. With reference to Figs. 3 and 4, an alternative embodiment to the present invention is shown for fabricating attenuators having losses less than 10 dB (but normally greater than 5 dB).

In Fig. 3, fibers 10′,12′ are shown. It will be appreciated that fibers 10′,12′ are identical in every respect to fibers 10 and 12 of Figs. 1 and 2. Accordingly, a detailed description of fibers 10′ and 12′ will not be given. The reader will note that the elements of fibers 10′ and 12′ are numbered identically to those of fibers 10 and 12 with the addition of apostrophes or prime designations.

Fibers 10′,12′ are held in anchors 40,42 which include threaded shafts 41,43 carried on platforms 44,46. As a result, anchors 40 and 42 may be raised or lowered relative to platforms 44,46. It will be appreciated that anchors for holding optical fibers 10′,12′ form no part of this invention per se. Such anchors are schematically shown in U.S. Patent No. 4,557,556 and U.S. Patent No. 4,557,557.

The anchors 40,42 firmly grip the fibers 10′,12′ and are spaced from the terminal ends 22′,24′ by a distance of about 2½ centimeters. In the embodiment of Fig. 3, the anchors 40,42 are initially placed such that the fibers 10′,12′ are disposed in side-by-side abutting relation to define an overlapped portion 26′ having a preferred length D_2 of about .35 millimeters. The overlapped portion 26′ is positioned between the electrodes 28,30. As shown in Fig. 3, the axis of X′-X′ and Y′-Y′ of the fiber cores 14′,16′ are disposed in parallel and offset relation at the location of the anchors 40,42.

The electrodes 28,30 are energized and the energy of the arc flowing between the electrodes 28,30 causes melting of the claddings 18′,20′ in the overlapped portion 26′. While the cladding 18′,20′ in the overlapped portion 26′ is in a semi-liquid state, the anchors 40,42 are moved relative to one another to bring the axes X′-X′ and Y′-Y′ in the region of anchor locations 40,42 to be in axial alignment. (Alternately, the fiber axis X′-X′ and Y′-Y′ may be aligned before the arc is applied). In Fig. 3, anchor 40 is indicated by arrow A as moving in an upward direction. Anchor 42 is indicated by arrow B to be moving in a downward direction. It will be appreciated that both of anchors 40 and 42 need not be moved. All that is required is that one of the anchors 40,42 moves relative to the other anchor to cause the axes X′-X′ and Y′-Y′ in the region of the anchors 40,42 to be in axial alignment.

The method described above results in a fused attenuator as shown in Fig. 4. As indicated in Fig. 4, the axes X'-X' and Y'-Y' are shown in axial alignment. We have found that this fabrication method permits fabrication of an attenuator of less than 10 dB. To further reduce the loss through the attenuator, subsequent applications of energy can be applied to the region 26a' to further move the cores 14',16' closer together. After each application of energy, the transmission loss through the fibers 10',12' is measured until the desired attenuator loss is achieved. We have found that the fiber cores 14,16 at overlapping section 26 approach one another and that attenuators having a loss of as low as 5 dB are attainable with the present technique.

Referring now to Fig. 5, a still further embodiment of the present invention is shown. In Fig. 5, fibers 10'' and 12'' are shown having cores 14'',16'' surrounded by claddings 18'' and 20''. The fibers 10'' and 12'' are identical to fibers 10 and 12 except that at the terminal ends 22'',24'' fibers are provided with a reduced diameter portion in the form of a tapered areas 21'' and 23'' which taper the diameter of the cladding 18'',20'' from the full diameter D_0 to a reduced diameter D_R''. In a preferred embodiment, the reduced diameter D_R'' is about 0.5 millimeters. The length of the taper 23'' is about 2 millimeters.

As shown in Fig. 5, the fibers 10'' and 12'' are positioned similar to that of fibers 10 and 12 with the tapered portion 21'',23'' disposed in overlapping relation to define the overlapped portion 26''. The overlapped portion 26'' is then positioned between electrodes 28,30 and energy is applied to the overlapped portion 26'' to partially fuse the fibers 10'',12''. After application of the energy, the amount of attenuation is measured and subsequent applications of energy followed by subsequent measurements are performed

until desired attenuation is reached. Using the embodiment shown in Fig. 5, it is believed that attenuations as low as 1 dB can be obtained.

Fig. 6 shows a preferred use of an attenuator technique according to the present invention. In Fig. 6, an adapter 50 is shown. The adapter contains fibers 10 and 12 which have been fused at a fused portion 26a to achieve a desired amount of attenuation. Each of the fibers 10,12 are retained in axially aligned ceramic ferrules 52,54. The ferrules are contained within a housing 56 which includes a first mating portion 58 and a second mating portion 60.

The adapter shown in Fig. 6 is suited for use with so called D4 connectors. D4 connectors are well known in the art and form no part of this invention per se.

The attenuator 50 may be an in-line attenuator. Namely, by producing an attenuator according to the present invention, the attenuator 50 can have any one of a plurality of selected attenuation levels. A user can simply select an attenuator 50 having a desired attenuation level and couple it with a fiber optic line to input a desired attenuation into the optical transmission line. Further, attenuators 50 having varying levels of attenuation can be connected to one another having an additive effect on their attenuation levels.

From the foregoing detailed description of the present invention, it has been shown how the objects of the invention have been attained in the preferred manner. However, modifications and equivalence of the disclosed concepts, such as those which readily occur to one skilled in the art, are intended to be included within the scope of the claims which are appended hereto.

What is claimed is:

1. A method for fabricating an optical attenuator from at least a first and a second optical fiber having first and second cladding, respectively, surrounding first and second cores, respectively, said method comprising the steps of:

placing said first and second fibers in closely-spaced overlapping relation to define an overlapped portion of said fibers; and

initially applying energy to said overlapped portion to at least partially fused said first and second fibers at said overlapped portion.

2. A method according to claim 1 wherein said placing step includes disposing said fibers in side-by-side abutting relation at said overlapped portion.

3. A method according to claim 1 wherein said placing step includes placing said fibers in parallel alignment at said overlapped portion.

4. A method according to claim 1 further comprising initially measuring an attenuation through said overlapped portion after said initial application of said energy.

5. A method according to claim 4 further comprising applying an additional application of energy to said overlapped portion after said initial measuring and measuring said attenuation after said additional application.

6. A method according to claim 5 further comprising performing subsequent additional applications of

energy to said overlapped portion followed by subsequent additional measurement of said attenuation until a measured attenuation achieves a desired attenuation.

7. A method according to claim 1 wherein said placing step includes placing a first and second anchor location of said first and second fibers, respectively, in relative positioning with axes of said first and second cores offset at said first and second anchor locations; and
urging said first and second cores at said first and second anchor locations toward an axial alignment.

8. A method according to claim 1 comprising forming a reduced diameter portion on at least one of said first and second claddings and, in said placing step, positioning said reduced diameter portion at said overlapped portion.

9. A method according to claim 1 comprising applying said energy to move said cores toward one another.

FIG. 1

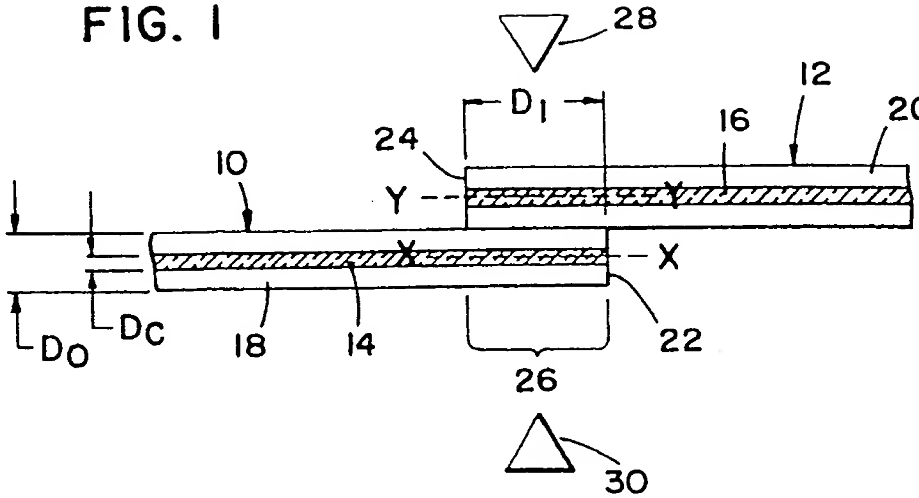


FIG. 2

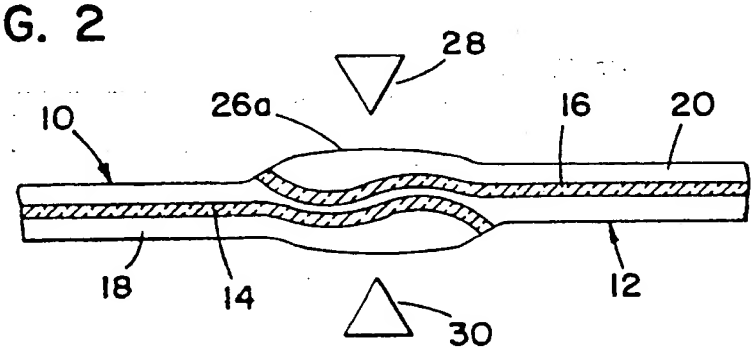


FIG. 3

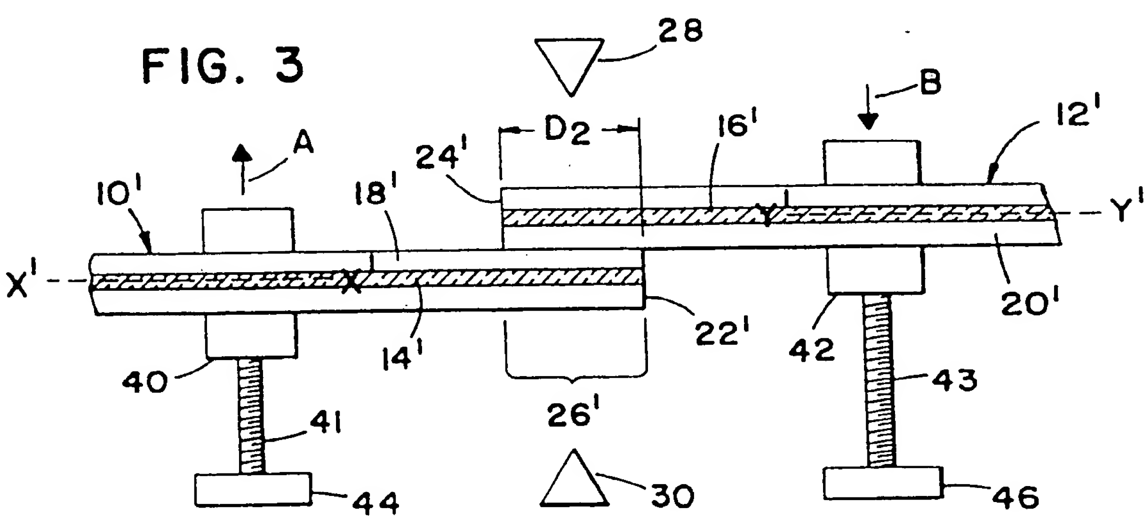
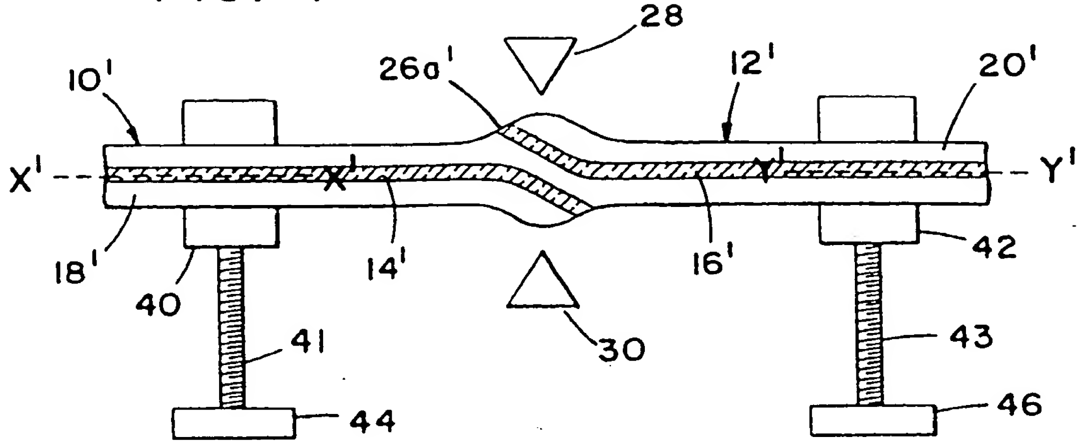


FIG. 4


28
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26a'
12'
20'
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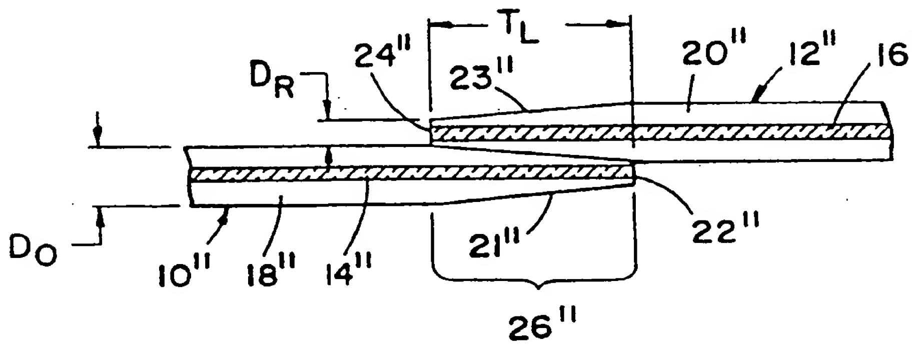
X'
Y'
Y'
18'
40
14'
16'
42
41
30
43
44
46

FIG. 5


T_L
D_R
24''
23''
20''
12''
16''
D_O
10''
18''
14''
21''
22''
26''

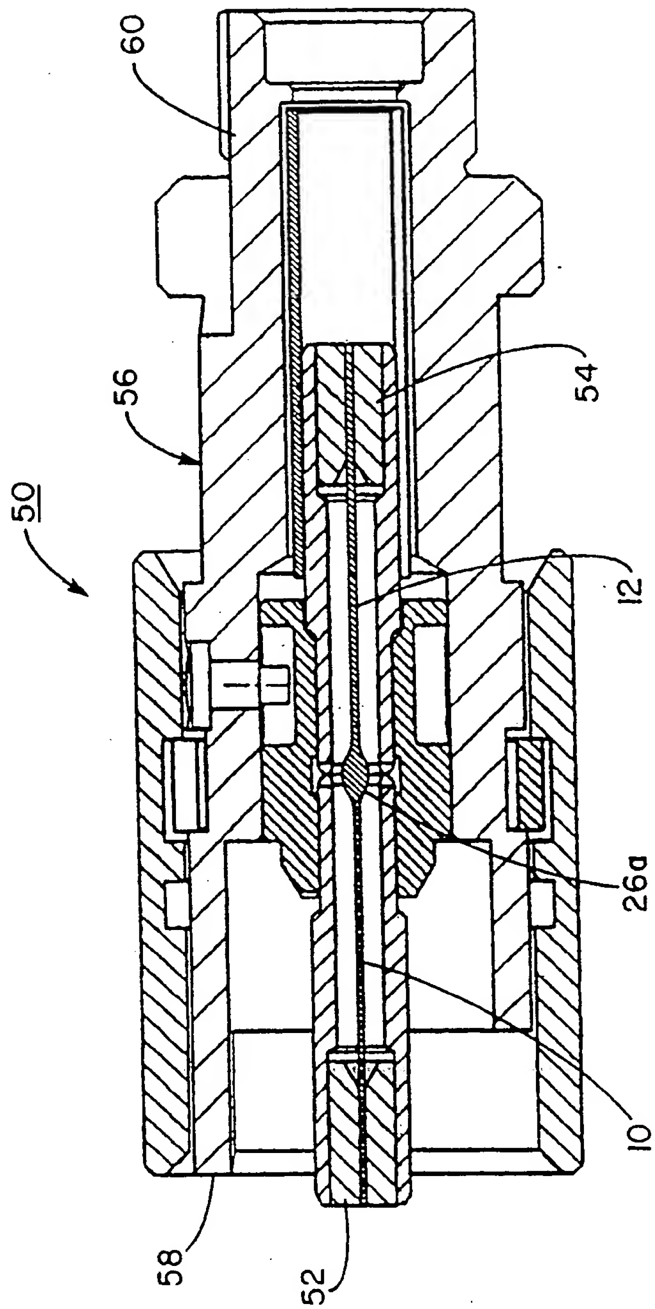


FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 92/07247

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G02B6/26; G02B6/28

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G02B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
Y A	DE,A,3 042 587 (LICENTIA) 1 April 1982 see claims; figures ---	1-3 4-9
Y	EP,A,0 404 587 (FUJIKURA) 27 December 1990 see claims; figures ---	1-3
A	GB,A,2 088 578 (SSD) 9 June 1982 see claims; figures ---	1
A	EP,A,0 411 350 (JAE) 6 February 1991 see claims; figures ---	1

-/--

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
19 NOVEMBER 1992	30. 11. 92
International Searching Authority EUROPEAN PATENT OFFICE	Signature of Authorized Officer PFAHLER R.

1

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US,A,4 557 557 (R.F.GLEASON) 10 December 1985 cited in the application see claims; figures ---	1
A	EP,A,0 144 136 (ATT) 12 June 1985 cited in the application see claims; figures ---	1
A	GB,A,2 140 167 (ATT) 21 November 1984 cited in the application see claims; figures -----	1

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. US 9207247 SA 64246

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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